546

Longline Fishing for Deep-Swimming Tunas in the Marquesas Islands and Adjacent Areas

By Howard O. Yoshida

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Longline Fishing for Deep-Swimming Tunas in the Marquesas Islands and Adjacent Areas

By

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ABSTRACT

Six hundred forty-two tuna, including 438 yellowfin tuna (Thunnus albacares), 102 bigeye tuna (T. obesus), 51 albacore (T. alalunga), and 51 skipjack tuna (Katsuwonus pelamis), were caught by longline fishing on three cruises across the Equator on long. 132° and 150° W. and around the Marquesas Islands (ca. long. 140° W.) between August 1956 and May 1958. These cruises were part of an investigation of fishery resources of the Marquesan area by the Bureau of Commercial Fisheries Biological Laboratory at Honolulu.

The distribution and abundance of yellowfin tuna are considered in greatest detail in this report, because this species dominated the catches. Yellowfin tuna were more abundant during the Southern Hemisphere summer than winter and on long. 132° W. than on long. 150° W.; also, they were more numerous in the "inshore," < 148 kilometers (80 nautical miles) from land, waters of the Marquesas than in the adjacent "oceanic" (> 148 kilometers from land) waters. Their abundance differed seasonally in the insular waters of the Marquesas.

Although bigeye tuna were not as abundant nor as widely distributed, their distribution was somewhat similar to that of yellowfin tuna.

No albacore were caught north of lat. 7° S. on long. 132° and 150° W. This distribution appeared to be associated with a discontinuity of the oceanic structure extending east-west around lat. 10° S.

INTRODUCTION

Investigations of the high-seas fishery resources of the tropical and subtropical Pacific Ocean by the Bureau of Commercial Fisheries Biological Laboratory at Honolulu[1/] have included sampling of deep-swimming tunas taken by longline in equatorial waters. The early investigations were designed to cover a vast area of the equatorial Pacific to delimit the general distribution and abundance of the deep-swimming tunas. This exploratory fishing revealed a concentration of yellowfin tuna (Thunnus albacares) along the Equator, with a zone of high abundance between long. 140° and 160° W. (Murphy and Shomura, 1953a, 1953b, 1955; Shomura and Murphy, 1955). Later investigations were centered on the distribution and abundance of yellowfin tuna around the Line Islands (Iversen and Yoshida, 1956, 1957), which are located within the general zone of high abundance.

After the completion of the investigations in the central equatorial Pacific, exploratory fishing was extended to the Marquesas Islands and adjacent areas. The longline fishing in this region, however, was ancillary to a more intensive study of the surface tunas. In addition, a small part of the fishing was expended towards testing certain hypotheses that had developed from results of previous work in the central equatorial Pacific.

There were three cruises to the Marquesas between August 1956 and May 1958 during which at least part of the time was spent in longline

[1/] Formerly known as the Pacific Oceanic Fishery Investigations (POFI).

fishing (fig. 1). The seasons and areas of fishing are given in table 1.

METHODS

Mann (1955) described in detail longline gear similar to that used for this study. The basic unit, the basket, was composed of a 384-m. mainline and eleven 5.5-m. hook droppers or branch lines attached to the mainline at 27.4-m. intervals. Forty-four to sixty of these baskets were joined to make a set. The set was buoyed by a series of floats attached to basket junctures by 18.3-m. float lines. The bait was frozen Pacific herring (Clupea harengus pallasi). Murphy and Shomura (1953a) described in some detail the manner in which longlines are set and retrieved. As a rule, they are set at dawn and retrieved at noon.

To estimate the depths fished by the longline, five or six sounding tubes were used regularly at each fishing station. They were attached to the sixth dropper, the middle dropper of the 11-hook basket, and were distributed evenly throughout the set. For each longline station the depths indicated by these sounding tubes were averaged and the mean depths were used to represent the mean maximum depth of the longline. At many stations additional sounding tubes were attached to the third, sixth, and ninth droppers of one basket to get an estimate of the configuration of the mainline.

The total lengths of all the tuna caught on the cruises were obtained by the method described by Marr and Schaefer (1949).

For some sections of this paper it was convenient to classify the fishing stations as "oceanic" or "inshore." The division between oceanic and inshore fishing stations was made at a distance of 148 kilometers (80 nautical miles) from land (following Shomura and Murphy, 1955). By this criterion, all of the stations fished on north-south transects on long. 132° and 150° W. were oceanic. The inshore stations were all near the Marquesas Islands.

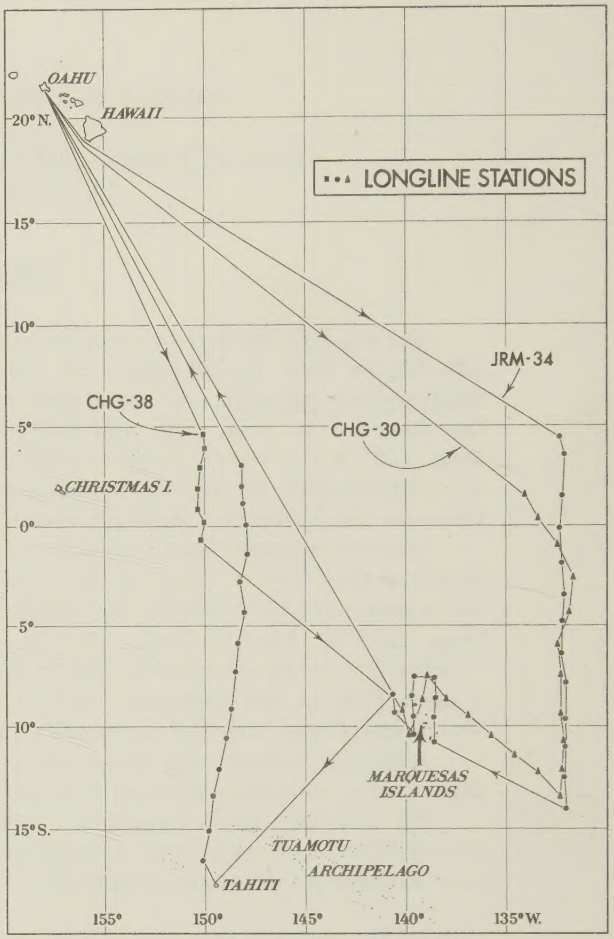

Figure 1.--Tracks of CHG (Charles H. Gilbert) cruises 30 and 38, and JRM (John R. Manning) cruise 34.

Table 1.--Summary of fishing by season and area, Charles H. Gilbert cruises 30 and 38 and John R. Manning cruise 34

Cruise	Season[1/]	Area fished
Charles H. Gilbert cruise 30	Winter (August-September 1956)	Long. 132° W. from lat. 1°32' N. to 12°07' S.; around Marquesas Islands and adjacent area.
John R. Manning cruise 34	Summer (January-March 1957)	Long. 132° W. from lat. 4°29' N. to 14°02' S.; around Marquesas Islands; long. 150° W. from lat. 16°34' S. to 3°01' N.
Charles H. Gilbert cruise 38	Summer (February 1958)	Long. 150° W. from lat. 4°44' N. to 0°45' S.

[1/] For Southern Hemisphere.

In the analysis of the results of fishing, the catch rates of yellowfin tuna and bigeye tuna (T. obesus), by season and area, were subjected to simple statistical tests. Catch rates from two or more independent areas or seasons were tested to see whether they could have been drawn from the same population (Mann-Whitney U test or the Kruskal-Wallis one-way analysis of variance by ranks--Siegel, 1956). I concluded that fish were relatively more abundant in one area or season if differences in the catch rates were significant.

Unless otherwise stated, all the seasonal designations in this paper refer to seasons in the Southern Hemisphere.

DISTRIBUTION AND ABUNDANCE OF TUNAS

The data on longline fishing from the three cruises already have been published (Austin, 1957; Wilson and Rinkel, 1957; and Wilson, Nakamura, and Yoshida, 1958). The tuna catch of these cruises totaled 642 fish, comprising 438 yellowfin tuna, 102 bigeye tuna, 51 albacore (T. alalunga), and 51 skipjack tuna (Katsuwonus pelamis).

The distribution and abundance of yellowfin tuna are considered in greatest detail, since this species dominated the catches.

Yellowfin Tuna

Previous investigations in the equatorial Pacific Ocean disclosed the presence of concentrations of yellowfin tuna within a band of latitude several degrees to the north and south of the Equator, and also indicated north-south and east-west shifts in these concentrations (Murphy and Shomura, 1953a, 1953b, 1955; Shomura and Murphy, 1955; Iversen and Yoshida, 1956).

In the winter of 1956, deep-swimming yellowfin tuna were caught from lat. 1°32' N. to as far south as lat. 13°26' S., the southernmost fishing station, on long. 132° W. (fig. 2). The catch rates were highest at the northernmost fishing station of the north-south transect and ranged from 0 to less than 1 fish per 100 hooks for the remainder of the transect. A rather discontinuous distribution is suggested.

The latitudinal range fished during the summer of 1957 on long. 132° W., was from lat. 4°29' to 14°02' S. Yellowfin tuna were found throughout this range and were relatively more abundant than in the previous winter (fig. 2 and table 2). The catch rate was highest at lat. 3°29' S. In the same season, but farther to the west, on long. 150° W., yellowfin tuna were less abundant and were irregularly distributed between lat. 3°01' N. and 16°34' S. (fig. 2 and table 2). The highest catch rate, 1.6 fish per 100 hooks, was at lat. 0°06' N. Another transect was fished on this meridian the following summer. On this 1958 transect, fishing was confined to a narrow band across the Equator, between lat. 4°44' N. and 0°45' S. Catches of yellowfin tuna again were rather low and were concentrated within a few degrees of latitude north of the Equator.

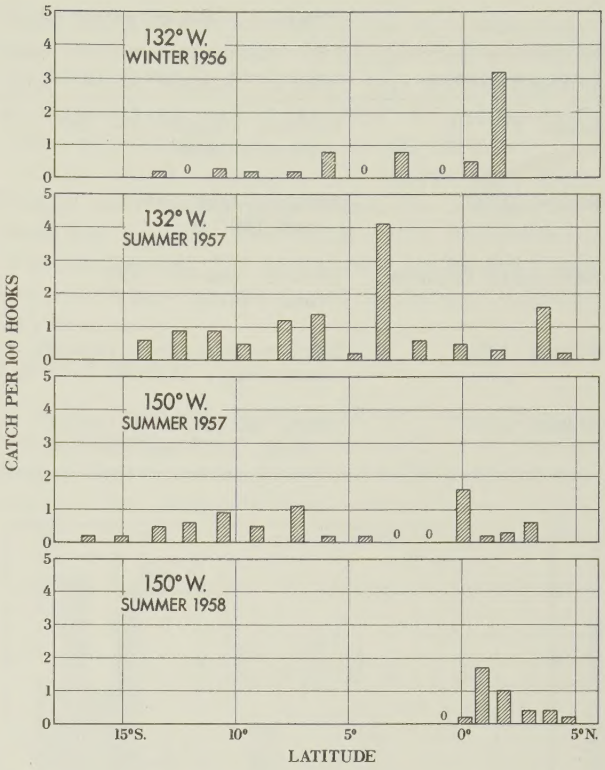

Figure 2.--Oceanic catch rates (number of fish per 100 hooks) for yellowfin tuna on long. 132° W., winter 1956 and summer 1957, and on long. 150° W., summers 1957 and 1958.

In summary it is evident that yellowfin tuna were relatively unavailable to longline fishing on long. 150° W. At long. 132° W., where a seasonal comparison can be made, yellowfin tuna were relatively more abundant in the summer than in winter. They also were more abundant to the east, at long. 132° W., than at long. 150° W., at least during the summer of 1957. In addition to these seasonal and longitudinal differences, relative abundance exhibited latitudinal shifts.

Table 2.--Catch rates of yellowfin tuna by season and area

Area or season	Comparison of catch rates	Test	Result
Long. 132° W.	Between summer 1957 and winter 1956	Mann-Whitney	$U = 35.5$, $n_1 = 11$, $n_2 = 13$; $p < 0.002$
Summer 1957	Between long. 132° and 150° W.	do	$U = 56$, $n_1 = 13$, $n_2 = 15$; $p < 0.002$
Marquesas Islands	Between summer 1957 and winter 1956	do	$U = 4$, $n_1 = 5$, $n_2 = 9$; $p < 0.002$
Winter 1956	Between Marquesas Islands and long. 132° W.	do	$U = 11$, $n_1 = 5$, $n_2 = 5$; p 0.421
Summer 1957	Among Marquesas Islands long. 132° and 150° W.	Kruskal-Wallis	$X^2 = 12.5078$, d.f. = 2; $p < 0.01$

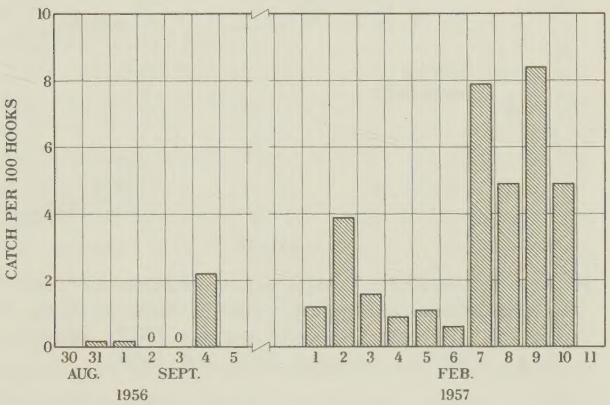

Figure 3.--Catch rates for yellowfin tuna (number of fish per 100 hooks) at the inshore stations.

The daily catch rates (fish per 100 hooks) of yellowfin tuna at inshore stations near the Marquesas Islands are presented in figure 3. The catch rate varied considerably from day to day (0 to 8.4 fish per 100 hooks). Seasonally yellowfin tuna were relatively abundant during the summer (table 2). The catch rates during the winter ranged from 0 to 2.2 fish per 100 hooks, but in the summer the range was 0.9 to 8.4. The Hawaiian longline fishery also shows a seasonality in abundance; greatest numbers are caught from May to September (Otsu, 1954). June (1953) suggested that the longline fishery in Hawaii is based on a spawning migration, for the months which have the highest catch rates for yellowfin tuna coincide with the period of greatest ovarian maturity. No comparable data on maturity are available from the Marquesas Islands. The occurrence of fish larvae, however, has been taken to indicate spawning areas and seasons by many workers, e.g., Matsumoto (1958). The abundance of yellowfin tuna larvae was observed during the periods covered by our longline fishing. Strasburg (1960) gave data on larvae captured in 1/2-hour surface plankton tows in an area around the Marquesas Islands bounded by lat. 7°32' and 12°48' S., long. 134°46' and 143°55' W. The larvae were captured at the rate of 0.02 per 1,000 $m.^3$ of water strained in winter and 1.65 per 1,000 $m.^3$ of water strained in summer. Furthermore, as will be shown later, the higher catch rates on longlines in summer may have resulted from an influx of larger, and presumably more mature, yellowfin tuna into the Marquesas area. They well may converge on this area to spawn during summer.

Strasburg (1958: p. 348) noted several ways in which the proximity of land can influence the distribution of marine animals: "For certain oceanic species the presence of land acts only as a barrier to movements, whereas others congregate about islands and other land masses to feed or to reproduce. It occasionally happens that oceanic fish abound in insular environments, either because of the islands' intrinsic nutritive richness or because they lie in the path of rich oceanic currents."

My data, although rather meager, provide information on the abundance of yellowfin tuna close to the Marquesas Islands as contrasted with the adjacent oceanic areas. For this comparison, the oceanic stations south of lat. 7° S. were selected. I believe that the effect of the equatorial enrichment system, in which yellowfin tuna are known to be relatively abundant, is not discernible this far south. During summer, the average catch rates were higher in the inshore waters of the Marquesas than in the ad-

jacent oceanic areas; catch rates differed little during winter (fig. 4 and table 2). In the equatorial Pacific Ocean, near the Line Islands, yellowfin tuna also tend to be more abundant near land than in the open ocean (Shomura and Murphy, 1955; Iversen and Yoshida, 1957).

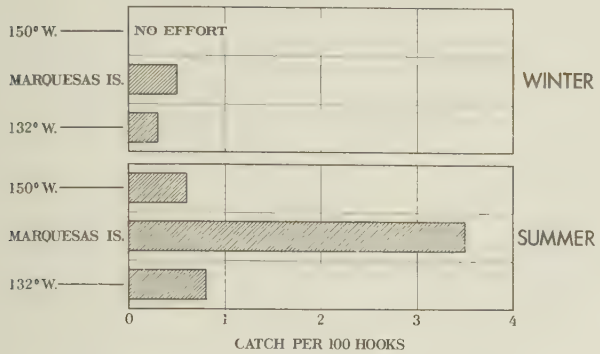

Figure 4.--Catch rates (number of fish per 100 hooks) for yellowfin tuna in the Marquesas Islands (inshore stations) and adjacent oceanic areas south of lat. 7° S.

Bigeye Tuna

The distribution of bigeye tuna differed from that of yellowfin tuna on long. 132° W. in the winter of 1956 (fig. 5). Their distribution was relatively limited along this meridian (between lat. 4° and 11° S.), whereas yellowfin tuna were found from about lat. 2° N. to 13° S. In the summer of 1957, however, bigeye tuna were more abundant and more widely distributed (lat. 4°29' N. to 14°02' S.) than they were in the winter of 1956 and their distribution closely paralleled that of yellowfin tuna (figs. 2, 5, and table 3).

Farther west, on long. 150° W., bigeye tuna were not as abundant nor as widely distributed as they were on long. 132° W. (fig. 5 and table 3). They were taken in small numbers between lat. 5°51' S. and 3°01' N. on this transect but were distributed discontinuously within these latitudes. In contrast, yellowfin tuna were found from lat. 16°34' S. to 3°01' N. on this meridian during the same period. Along long. 150° W. from lat. 4°44' N. to 0°45' S. the following summer, the distributions of bigeye and yellowfin tunas were similar, except that the peak catch of bigeye tuna was at lat. 0°53' N. and the peak catch of yellowfin tuna was at lat. 2°57' N.

Only small numbers of bigeye tuna were caught near the Marquesas Islands in both summer and winter. The catch rates varied from 0 to 0.8 fish per 100 hooks and, unlike the rates for yellowfin tuna, displayed no marked seasonal difference.

Other Tunas

Small numbers of skipjack tuna and albacore were caught along with yellowfin and bigeye tunas. Deep-fishing longlines do not effectively sample the skipjack tuna, which is a small,

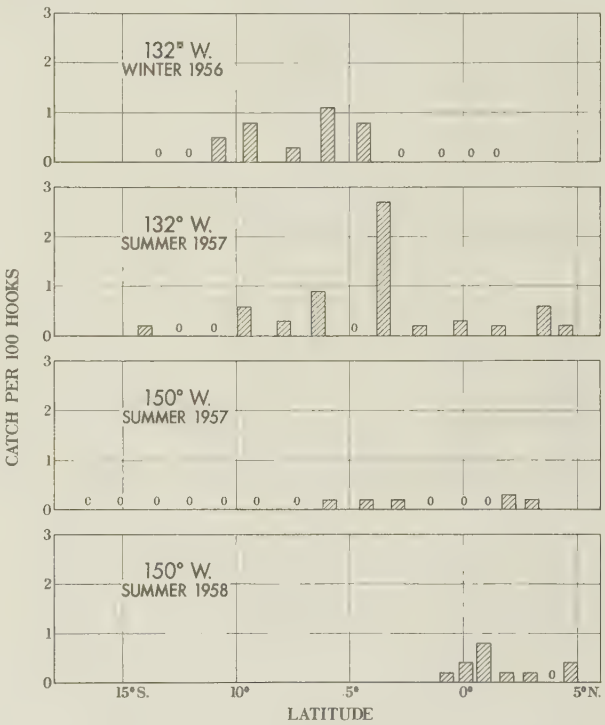

Figure 5.--Oceanic catch rates for bigeye tuna (number of fish per 100 hooks) on long. 132° W., winter 1956 and summer 1957, and on long. 150° W., summers 1957 and 1958.

Table 3.--Catch rates of bigeye tuna by season and area

Area or season	Comparison of catch rates	Test	Result
Long. 132° W.	Between summer 1957 and winter 1956	Mann-Whitney	$U = 60$, $n_1 = 11$, $n_2 = 13$; $p < 0.002$
Summer 1957	Between long. 132° and 150° W.	do	$U = 43$, $n_1 = 13$, $n_2 = 15$; $p < 0.002$

surface-schooling species (Shomura and Murphy, 1955). Around the Marquesas Islands, where they are abundant (Wilson, MS.[2/]), longlines catch only small numbers. Catches of this fish on long. 132° and 150° W. also were small and sporadic.

Albacore first began to appear in the catches at about lat. 7° S. on long. 150° W. and at about lat. 11° S. on long. 132° W. The number caught at any one station was small. This distribution of albacore is interesting in light of the observations by Yamanaka (1956) in the western South Pacific. Yamanaka noted a conspicuous discontinuity, characterized by sharp changes in water temperature, salinity, and sigma-t values, in the oceanic structure running in an east-west direction and centered on lat. 10° S. He suggested that this discontinuity probably limits distribution of albacore in the southwest Pacific. Our observations on the oceanic structure in this area indicate that this discontinuity extends as far east as long. 132° W.

Only small numbers of albacore were taken around the Marquesas Islands in both winter and summer; the catch rates ranged from 0 to 2.2 albacore per 100 hooks.

VERTICAL DISTRIBUTION OF TUNAS

Iversen and Yoshida (1957) showed that the longlines tend not to fish as deep near the Equator as they do several degrees to the north. They suggested that this difference was caused by the shear between the westerly South Equatorial Current at the surface and the easterly Equatorial Undercurrent beneath. In general, results were similar on the north-south fishing transects across the Equator on long. 132° and 150° W. (fig. 6). The mean maximum depths reached by the longlines within about 2° north and south of the Equator were not as great as those recorded farther north or south; this trend was not strongly evident during Charles H. Gilbert cruise 38.

The Pacific Equatorial Undercurrent first was described by Cromwell, Montgomery, and Stroup (1954). Knauss and King (1958), who measured the velocities of the Undercurrent, found that it was symmetrical about the Equator and that the core of the current was flowing between 2 and 3.5 knots at 0°, long. 140° W. They also found that the Undercurrent was weaker on either side of the Equator; the velocity was 0.6 knot at lat. 2° N. and 2° S. The depths reached by our gear demonstrate this configuration, because the longlines usually were shallowest at the Equator, where the velocity of the Undercurrent is greatest, and became deeper on either side, where the Undercurrent is weaker.

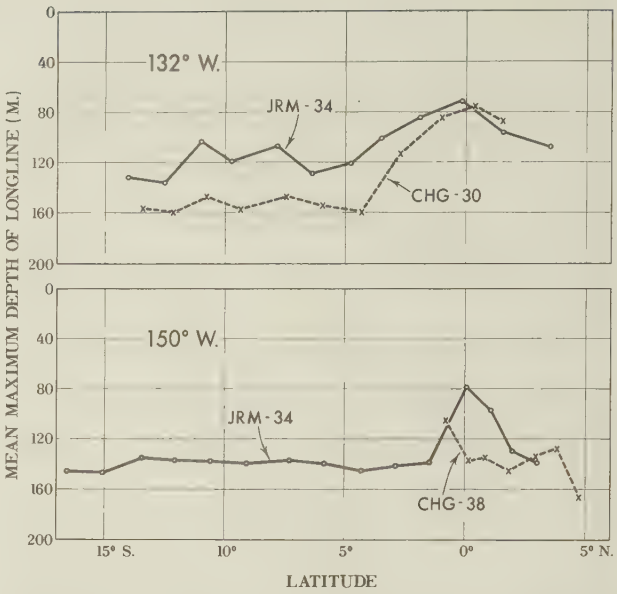

Figure 6.--Latitudinal variation of the mean maximum depths of longline gear on long. 132° and 150° W. CHG is Charles H. Gilbert and JRM is John R. Manning.

Longline catches have been used to evaluate the vertical distribution of tunas (Murphy and Shomura, 1953a, 1953b, 1955; Shomura and Murphy, 1955). Chemical sounding tubes attached to the gear have provided estimates of the absolute depths of the longlines, and accordingly, the vertical distribution of tunas (Shomura and Otsu, 1956; Iversen and Yoshida, 1957). Catches of tunas usually have been greatest on the deeper hooks of the longline. For example, Murphy and Shomura (1955: p. 27) stated that "...yellowfin are usually but not consistently more abundant at the deeper levels in the equatorial Pacific, the best bigeye catches are more regularly associated with the deeper fishing levels, and albacore are clearly caught in greatest abundance on the deepest fishing hooks."

To determine the vertical distribution of tunas, the catch rates for all stations were combined and averaged by species according to

[2/]Wilson, Robert C. MS. The surface tuna resources of the Marquesas Islands. Division of Foreign Fisheries, Bureau of Commercial Fisheries, Washington, D.C. 20240.

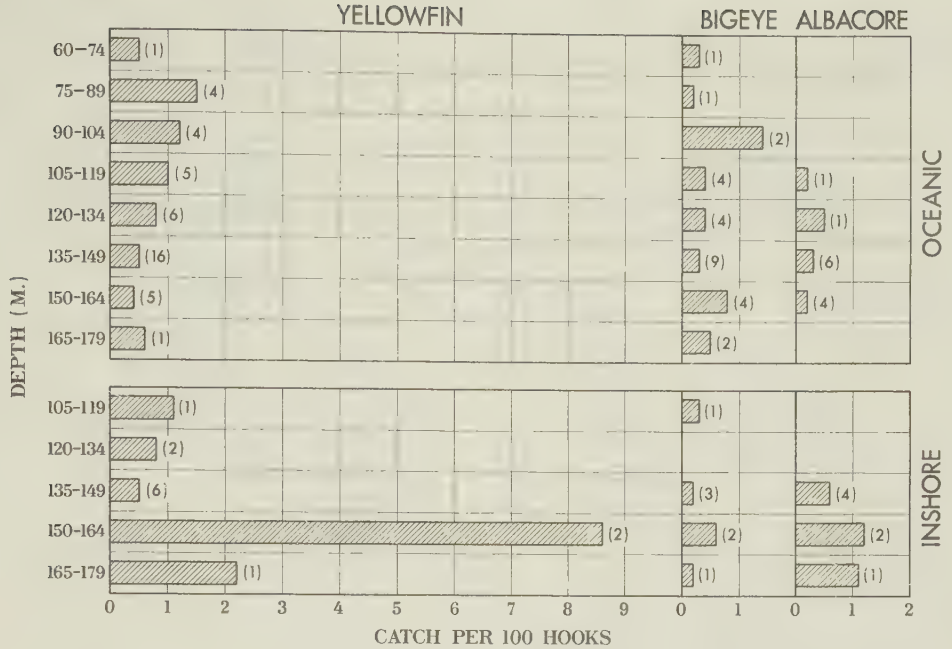

Figure 7.--Vertical distribution of longline catches of tunas at oceanic and inshore stations. Figures in parentheses are number of stations used in calculating the average catch rate (number of fish per 100 hooks).

the average maximum fishing depth of the longlines by 15-m. depth intervals. No zero catch rates were used in calculating the averages. The vertical distribution of tunas at oceanic stations is shown in figure 7. Yellowfin tuna were caught at all fishing depths; the highest catch rate was at the 75- to 89-m. depth. Complicating factors were latitudinal differences in both the catch rates and the depths at which the longlines fished. For example the depth at which longlines fish is relatively shallow near the Equator and here the catch rate of yellowfin tuna was greatest. Therefore, the peak catch rate at the 75- to 89-m. depth may be merely a reflection of the greater abundance of yellowfin tuna close to the Equator, or on the other hand, it may indicate that the vertical distribution of yellowfin tuna is real and that more are caught here because the longlines fish the depths in which tuna are most abundant.

Bigeye tuna, like yellowfin tuna, were caught at all depths fished. The highest catch rates were at 90 to 104 m. Here again, it is difficult to assess the relative influence of the areal distribution and the vertical distribution of the tunas.

As has been noted, no albacore were caught north of lat. 7° S. It could be argued that the longlines did not fish deep enough north of lat. 7° S. to catch them. This argument is apparently not valid, however, for the longlines fished as deep between lat. 2° and 5° N. and 4° and 7° S., as they did south of 7° S. It can be seen (fig. 7) that albacore were distributed rather evenly between 105 and 164 m.

The longlines fished relatively deep around the Marquesas--112 to 166 m., average maximum depth. The vertical distribution of tunas in this area is shown in figure 7. Although yellowfin tuna were caught at all depths, greater catch rates were within the two deepest strata. Bigeye tuna were caught between 105 and 169 m. with more fish taken in the 150- to 164-m. range.

SIZE OF TUNAS

Longlines typically catch greater numbers of the larger tuna than does pole and line or troll fishing, either by inherent selectivity of larger fish by the longlines or because the deep-swimming populations are made up chiefly of large fish (Murphy and Shomura, 1953a). The length-frequency distributions of oceanic and inshore catches of yellowfin tuna (fig. 8) indicate essentially no difference. The length

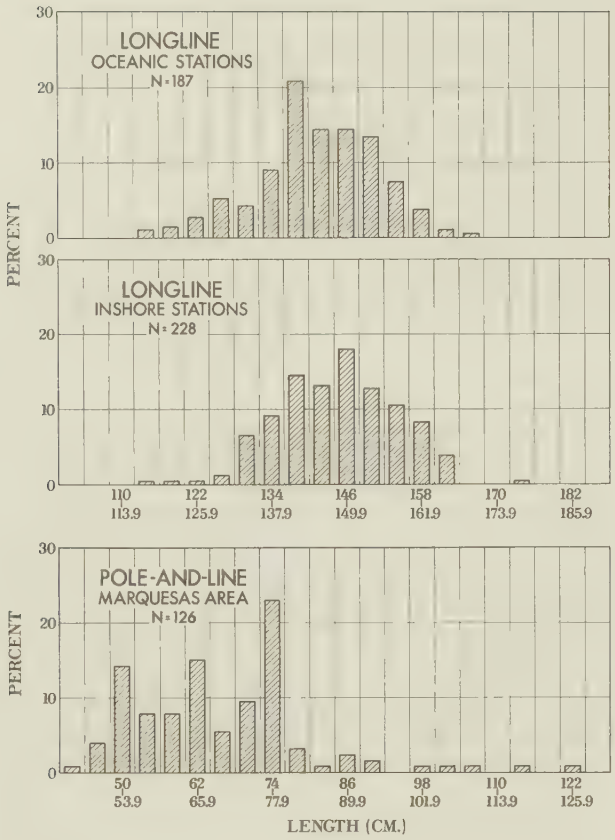

Figure 8.--Length-frequency distributions of yellowfin tuna caught by longlines at oceanic stations, inshore stations, and on pole and line in the Marquesas area (pole-and-line data from Wilson and Rinkel, 1957, and Wilson et al., 1958).

ranges were about equal and the dominant sizes were similar. This situation is at variance with that around the Line Islands. Although the catches there also are dominated by large yellowfin tuna, more small fish (50-110 cm.) are caught near the Line Islands than offshore (Shomura and Murphy, 1955; Iversen and Yoshida, 1957). No yellowfin tuna smaller than 114 cm. were caught by longlining around the Marquesas, although their presence was shown by catches made by pole-and-line fishing (fig. 8). Fish between 90 and 130 cm. were sparsely represented in catches of both longline and pole and line. This result may indicate that the smaller yellowfin tuna in that size range were not present in great numbers or that neither fishing method adequately samples them.

The possibility has been mentioned that the seasonally greater abundance of yellowfin tuna around the Marquesas during the summer may have been caused by an influx of large fish.

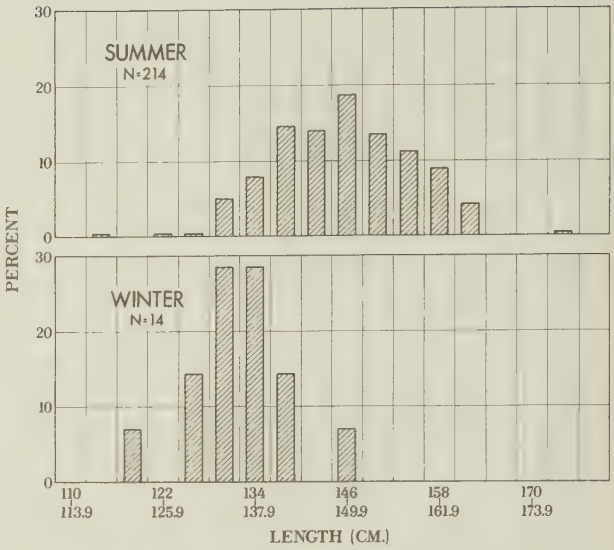

Figure 9.--Length-frequency distribution of yellowfin tuna in the Marquesas Islands, arranged by season.

The length-frequency distribution of fish caught in this area, arranged by season (fig. 9) shows that no fish longer than 150 cm. were caught during winter and that their modal size was between 130 and 138 cm. In the summer about 36 percent of the catch was composed of fish longer than 150 cm., and the mode was at 146-150 cm. These data should be viewed with caution, however, for the winter sample consisted of only 14 yellowfin tuna.

Length-frequency distributions of skipjack tuna, albacore, and bigeye tuna are presented in figure 10. These tunas were not caught in sufficient numbers to warrant detailed comments. The modes in the length-frequency distributions of bigeye tuna are indefinite; however, 85 percent of the bigeye tuna were between 126 and 178 cm. long. The size distribution of albacore was relatively compact: All of the specimens measured between 90.6 and 111.6 cm., a length range of only 21 cm. Skipjack tuna ranged from 46.6 to 83.1 cm., and had a mode at 74-78 cm.

SUMMARY

1. This report is based on the tuna catches made by longline fishing on three cruises around the Marquesas Islands and across the Equator on long. 132° and 150° W. Six hundred forty-two tuna were caught, of which 438 were yellowfin, 102 bigeye, 51 albacore, and 51 skipjack.

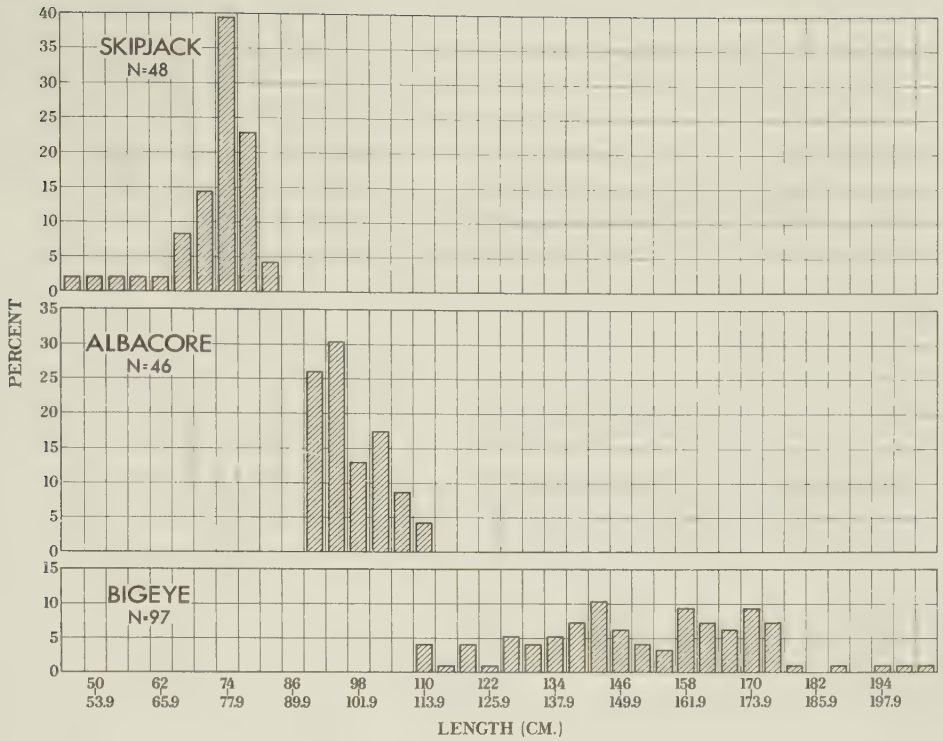

Figure 10.--Length-frequency distributions of skipjack tuna, albacore, and bigeye tuna.

2. Yellowfin tuna were the most abundant and widely distributed species of deep-swimming tunas in the oceanic areas. Where areal and seasonal comparisons could be made, they were more abundant on long. 132° W. than on 150° W., and during the Southern Hemisphere summer than during winter. The concentrations also showed apparent north-south shifts. Yellowfin tuna also were more abundant in the inshore waters of the Marquesas than in oceanic waters south of lat. 7° S.

3. The abundance of yellowfin tuna around the Marquesas varied seasonally. The presence of greater numbers of larger, and presumably more mature, fish and the occurrence of greater numbers of the larvae during the summer, suggest that they gather in this area to spawn.

4. Although bigeye tuna were not as abundant or widely distributed, their distribution, in general, was somewhat similar to that of yellowfin tuna. The greatest relative abundance of bigeye tuna was to the east (long. 132° W.) and during the Southern Hemisphere summer; they also showed north-south shifts in centers of concentration. Only small numbers of this species were taken near the Marquesas.

5. No albacore were caught north of lat. 7° S. on long. 132° and 150° W. There are indications that an east-west discontinuity of the oceanic structure around lat. 10° S. somehow may restrict the distribution. Like bigeye tuna, albacore were not very abundant at the inshore stations around the Marquesas.

6. Longlines did not fish as deep between lat. 2° N. and 2° S. as they did farther to the north and south. This fact was ascribed to shearing between the westerly flowing South Equatorial Current at the surface and the easterly flowing Equatorial Undercurrent beneath.

7. No conclusive statement could be made of the depths at which oceanic yellowfin and bigeye tunas were most abundant. Both species, however, were caught at all depths fished by the longlines. Oceanic albacore south of lat. 7° S. were evenly distributed between 105 and 164 m. Near the Marquesas Islands catches of yellowfin tuna were often greater when the longlines fished deeper. Catches of bigeye tuna were greatest between 150 and 164 m. Albacore were deeper than yellowfin or bigeye tunas.

8. The length-frequency distributions of yellowfin tuna caught at oceanic stations and at stations near the Marquesas Islands were similar; yellowfin tuna from 90 to 130 cm. long were sparsely represented in catches near the Marquesas. Fish in this size range possibly

are not present in any great numbers in this area.

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